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ACOUSTIC REMOTE SENSING OF LARGE-SCALE TEMPERATURE VARIABILITY IN THE NORTH PACIFIC OCEAN

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ABSTRACT

Large-scale, depth-averaged temperatures have been measured by long-range acoustic transmissions in the North Pacific Ocean for the past nine years. Acoustic sources located off central California and north of Kauai transmitted to receivers distributed throughout the North Pacific from 1996 through 1999 during the Acoustic Thermometry of Ocean Climate (ATOC) project. The Kauai transmissions resumed in early 2002 and are now continuing as part of the North Pacific Acoustic Laboratory (NPAL) project (Fig. 1); a six-year time series has been obtained so far. Even at long time and large spatial scales the ocean is highly variable. The paths from Kauai to California show a modest cooling trend (longer travel times) until the present time (Fig. 2). A path to the northwest showed modest warming and a weak annual cycle from 1999 until early 2003, when a strong annual cycle returned. In retrospect, these changes stemmed from the warming of the central Pacific associated with the Pacific Decadal Oscillation (PDO) that occurred in this interval. Comparisons between measured travel times and those predicted using ocean models, constrained by satellite altimeter and other data, show significant similarities and differences (Fig. 2). The acoustic data ultimately need to be combined with sea-surface height data and upper-ocean drifting-float data from Argo to determine the complementarity of the various data types. In particular, combining the acoustic and Argo data by inverse techniques will quantify the ability of the float data to resolve large-scale, upper-ocean heat content and the ability of the acoustic data to resolve abyssal temperature changes.

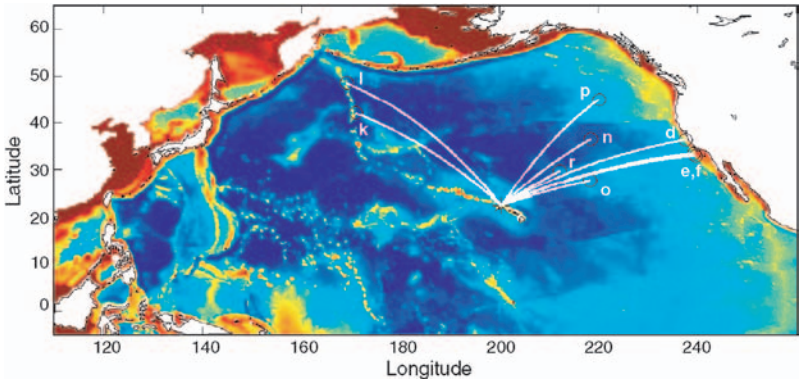

FIGURE 1. The NPAL array.

REFERENCES

ATOC Consortium (A. B. Baggeroer, T. G. Birdsall, C. Clark, J. A. Colosi, B. D. Cornuelle, D. Costa, B. D. Dushaw, M. Dzieciuch, A. M. G. Forbes, C. Hill, B. M. Howe, J. Marshall, D. Menemenlis, J. A. Mercer, K. Metzger, W. Munk, R. C. Spindel, D. Stammer, P. F. Worcester, and C. Wunsch), Ocean climate change: Comparison of acoustic tomography, satellite altimetry, and modeling, *Science*, 281, 1327–1332 (1998). [1]

Dushaw, B.D., Acoustic thermometry in the North Pacific, *CLIVAR Exchanges, 8* (1), 15-16, 20-22, 2003. [2]

Dushaw, B.D., Inversion of multimegameter-range acoustic data for ocean temperature, *I.E.E.E. Journal of Oceanic Engineering*, *24*, 215-223, 1999. [3]

Dushaw, B., G. Bold, C.-S. Chiu J. Colosi, B. Cornuelle, Y. Desaubies, M. Dzieciuch, A. Forbes, F. Gaillard, A. Gavrilov, J. Gould, B. Howe, M. Lawrence, J. Lynch, D. Menemenlis, J. Mercer, P. Mikhalevsky, W. Munk, I. Nakano, F. Schott, U. Send, R. Spindel, T. Terre, P. Worcester, & C. Wunsch, Observing the ocean in the 2000's: A strategy for the role of acoustic tomography in ocean climate observation, In: *Observing the Ocean in the 21st Century*, C. J. Koblinsky and N. R. Smith (eds.), Bureau of Meteorology, Melbourne, Australia, 391–418 (2002). [4]

Dushaw, B. D., B. M. Howe, J. A. Mercer, R. C. Spindel, & the ATOC Group (A. B. Baggeroer, T. G. Birdsall, C. Clark, J. A. Colosi, B. D. Cornuelle, D. Costa, B. D. Dushaw, M. A. Dzieciuch, A. M. G. Forbes, B. M. Howe, D. Menemenlis, J. A. Mercer, K. Metzger, W. H. Munk, R. C. Spindel, P. F. Worcester, C. Wunsch), Multimegameter-range acoustic data obtained by bottom-mounted hydrophone arrays for measurement of ocean temperature, *I.E.E.E. Journal of Oceanic Engineering*, 24, 202–214 (1999). [5]

Munk, W., P. Worcester, and C. Wunsch, *Ocean Acoustic Tomography*, Cambridge University Press, Cambridge, England, 433 pp. (1995). [6]

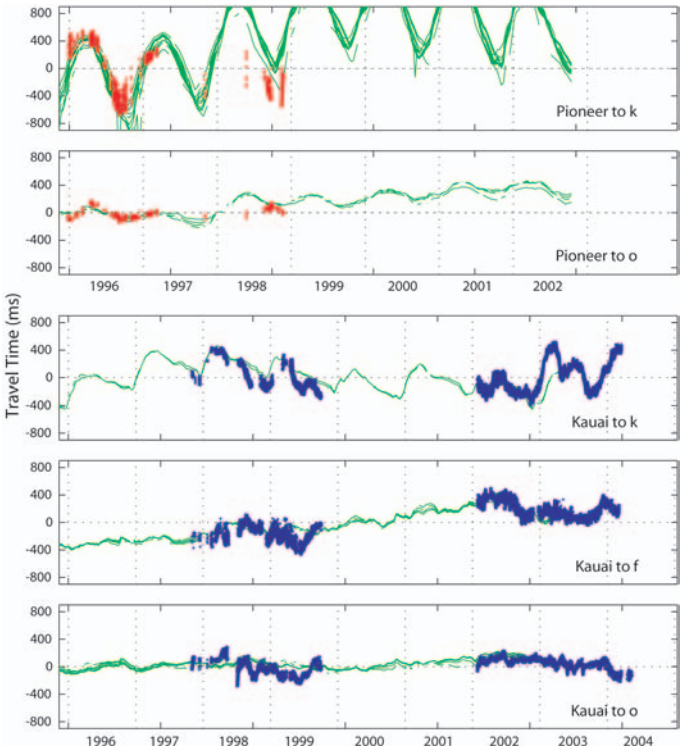

Figure 2. Travel times measured on the 1–5-Mm-long acoustic paths (red and blue) compared to travel times predicted using the JPL-ECCO ocean model (green). See Fig. 1 for path identification. Six to twelve rays are resolved and identified on each acoustic path.